

Controls on Nutrient Limitation in the Coastal Ocean

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LONG-TERM GOAL

My long term goal is to evaluate controls on nutrient limitation in the coastal ocean using an interdisciplinary approach combining geochemical, biochemical, and biological assays. I am particularly interested (i) in assessing the role of phosphorus (P) as a limiting nutrient in the coastal ocean; (ii) in the phenomenon of seasonal shifts in limiting nutrient(s) (e.g. between nitrogen (N) and P); and (iii) how such shifts influence phytoplankton species distributions.

OBJECTIVES

I wish to establish whether phosphorus acts as a limiting nutrient in coastal systems, how pervasive P-limitation is in both space and time, and how nutrient limitation dynamics may affect phytoplankton population distributions. While there is mounting evidence that nutrients other than N limit primary production in marine systems, the assumption of N-limitation is still pervasive. There is a need for studies which focus on simultaneous determination of all bioavailable forms of nutrients in a system, and couple this information to data which constrain the identity of limiting nutrient(s), such as enzymatic assays and bioassays. This study takes such a multi-faceted approach, and where possible views these data within the context of phytoplankton species distributions. Indications thus far from this study are that nutrient limitation in the coastal ocean is a dynamic process, with the identity of the limiting nutrient(s) shifting on seasonal time-scales.

APPROACH

I have collected seasonal sample suites during three years work on the Eel River Shelf, northern California. I occupied a sampling grid consisting of 4 to 5 shore-perpendicular transects, mostly concentrated between 30 to 70 m water depth (although some deeper sites were sampled on some transects; up to 450 m). These water samples were filtered ship-board for dissolved (inorganic + organic) nutrient, DOC and Alkaline Phosphatase (APase) analysis, and particulates were collected for chl-a, photopigment, CHN, TSS, P-speciation, and APase analysis. Additionally, I have similar sample suites from a seasonal study in the Gulf of Maine, and from the CalCOFI grid. These samples are targeted for APase analysis. A final component of the study is to search available data bases for data sets that will allow evaluation of the limiting nutrient status of other coastal systems on a seasonal basis.

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WORK COMPLETED

Optimization of a new generation, temperature-controlled fluorescence plate reader (a Cytofluor 4000) is nearly complete. The temperature control feature permits us to generate enzyme kinetic curves for determination of APase activity in natural water samples; previous generations of Cytofluors did not offer this feature. Analysis by fluorescence plate reader should increase our sample through-put by 100-fold over more traditional (fluorometer) methods. We are in the midst of performing sea-trials of the instrument. Demonstrating the potential to complete enzymatic analyses real-time at sea would be of huge benefit to future field studies.

We have identified and done a substantial amount of work on an extensive coastal ocean data set which has the requisite sampling scheme and parameters to evaluate limiting nutrient dynamics. The LATEX seasonal data set (nutrients, chl-a, oxygen, PAR) from the coastal Gulf of Mexico shows strong evidence for seasonal changes in the limiting nutrient regime.

Data and sample analysis are in progress.

RESULTS

In the first archived data set we have explored, the LATEX data set from the Gulf of Mexico, we find strong evidence for seasonally shifting nutrient limitation dynamics. This finding suggests that this phenomenon is not limited to our original study site, the Eel River Shelf, but may be a more pervasive phenomenon in the coastal ocean.

Additional analyses of data and samples from the Eel River Shelf sample suite are consistent with our original finding of seasonal P-limitation in this system.

IMPACT/APPLICATION

The work completed thus far, demonstrating P-limitation in a coastal ocean system and seasonal shifts in limiting nutrient dynamics in the coastal ocean, contributes to the growing appreciation of the complexity of nutrient limitation of primary production. As evidence of potential impact of and interest in this work, I have been invited to give talks in two special sessions at the upcoming AGU-ASLO Ocean Sciences meeting.

Developing and optimizing a method for APase assays on a fluorescence plate reader should be highly valuable in field studies of enzymatic parameters such as APase. The high degree of spatial heterogeneity common in aquatic systems demands broad sample coverage and, therefore, large numbers of analyses. Increasing sample through-put by 50x to 100x over traditional methods, such as we are proving possible with the Cytofluor, is a significant advance in our abilities to accurately characterize natural ecosystems.

TRANSITIONS

RELATED PROJECTS

I am participating in an AFCEE-funded project to determine the nutrient limitation status of a lake on the Otis Air Force Base Superfund site which is being impacted by a groundwater sewage plume. In

order to determine the extent of the potential impact, the nutrient limitation status of the lake must first be verified. I am using the methods developed in this and previous ONR-funded work (APase and DOP analyses) in the AFCEE project.

REFERENCES

PUBLICATIONS

Ruttenberg, K.C. The global biogeochemical cycle of phosphorus. Invited submission to the Encyclopedia of Global Change, Oxford University Press; in revision.

Monaghan, E.J. and Ruttenberg, K.C. (1999). Measurement of total dissolved phosphorus in the coastal ocean: A reassessment of available methods and an examination of seasonal water column phosphorus profiles from the Eel River Shelf. *Limnol. Oceanogr.* (in press for Nov. '99 issue).